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Art. XI.—*Notes on the Geology of the Coburg Area.*

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(Communicated by Professor E. W. Skeats).

(With Plate XVII.)

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Introduction.

The area that will be discussed in this paper is about four square miles of country to the east and north of Pentridge Stockade. It has been mapped by the Geological Survey of Victoria on quarter sheets (Nos. 1 N.E. and 1 N.W.), but the independent mapping of the writer shows slight differences from that of the quarter sheet. (For this independent mapping the contours were obtained from a map published by the Metropolitan Board of Works.)

The following stratigraphical horizons occur :—

Palaeozic -	Silurian sediments.
Tertiary -	Basic dykes.
	Tertiary sands.
	Sub basaltic gravels and sands.
	Newer Basalt.
Recent -	River alluvium.

Physiography.

The area constitutes a portion of the peneplain around Melbourne, and is drained by the Merri Creek. The country is of an average height of 200 feet above sea level. To the West and North basalt occurs, and forms a nearly uniformly flat plain, the highest level of which is about 240 feet. Through this basalt plain in the North, the Merri Creek follows a rather sinuous course, flowing between narrow V-shaped valleys, and over rapids and miniature waterfalls, with an average grade of 1 in 170. These are all characteristics of a stream young in development. To the South, however, where the stream is flowing through Silurian or along the junction of Silurian and basalt, the grade flattens to 1 in 480, and the valleys widen out. The pre-basaltic Merri was a mature stream, and did most of the work in the peneplanation of the area. After, however, the outpouring of the basalt it was rejuvenated, and now in the Northern area is rapidly cutting down into the basalt, and into the Silurian in places towards the South.

There is also evidence in the area of the Merri having changed its course in recent times. Just North of the Pentridge Stockade, on the North bank of the Merri a recent alluvial flat occurs. Through this flat a creek meanders, which may be termed "Falls Creek." From its headwaters down to the alluvial flat this creek is very young; in fact, it enters the flat over a waterfall formed by a bar of Silurian rock. In all probability the Merri Creek, which now cuts across the South boundary of the alluvial flat, formerly flowed right round its Northern boundary. This would account for the sudden change in the grade of Falls Creek. This change of course of the Merri is post basaltic in age, for the alluvial flat contains occasional boulders of Silurian and of basalt.

Stratigraphy.

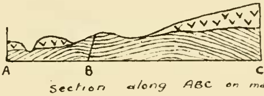
Silurian.—This series consists of the fine sandstones and shales of the Melbournian division of the Victorian Silurian. South of the Bell Street bridge a river cliff section shows a very good ripple marked surface on an exposure of one of these beds. The hollows average three inches in diameter.

No fossils were found in these rocks. The beds are only folded to a medium extent, giving a general strike 10 deg. East of North, and the dips in general are about 30 deg. In the area studied the beds usually dip to the West, but occasionally a small anticline and syncline occur, giving a few minor Easterly dips. The preservation of the North and South ridge to the East of Falls Creek is probably due to the compression of the rocks caused by such a local pucker. This method of preservation is also exemplified by the Silurian ridge North of the Coburg Cemetery. The road section just to the West of the cemetery shows a somewhat complicated pucker in the Silurian, which pucker can be traced South over Bell Street. In this connection it is significant that these two ridges have a North and South direction, i.e., a direction parallel to the strike, and to the major fold axes of the rocks.

The Silurian also shows evidence of faulting in a North and South direction. In the bend (concave to Pentridge) of the Merri just North of Pentridge, Silurian outcrops in the bed of the stream.

This outcrop is much shattered and fractured, and it is difficult to determine the strike and dip of the beds. A hard band of breccia striking North and South forms a miniature waterfall. This breccia is composed of angular and rounded Silurian fragments set in a finer paste of the same material, and the whole is iron-stained and cemented with limonitic material. Silica solutions also seem to have played a part in the cementation, for some of the breccia has the nature of a quartzite. The breccia is probably due to a North and South fault. The hade is obscured, but what evidence there is points to a Westerly one. A similar breccia occurs in an inlier of Silurian to the North-West of this last outcrop. The direction of the fault is obscure, there being only the one outcrop in the walls of a road section running North and South. The fault, however, appears to be an East and West one, hading to the South. This would suggest that pressures along both North and South, and East and West lines have occurred, and have produced both folding and faulting along these directions. This conclusion is further borne out by a road section cutting through the Silurian inlier. The latter is seen to be the axis of an E. and W. syncline, to which fact it probably owes its preservation. To the N.E. of this inlier

Section along Murray St — Vertical Scale 1 inch = 400 — Horizontal Scale 1 inch = 2640



Section along ABC on map

again, in a river section near the waterfall on Falls Creek, the same E. and W. folds are again seen, this time in an anticlinal axis. These East and West folds show very low dips, and undoubtedly the dominant fold movements are those in a North and South direction.

A river section just N.E. of the northern end of Sydney Road, and just North of Pentridge Stockade, shows the basalt resting upon the tilted and eroded surface of the Silurian sediments. The Silurian mudstones dip in a Westerly direction at 25 to 30 deg. The joint planes and bedding planes just beneath the basalt are filled with an impure limestone, which represents material leached out of the basalt, and deposited in the spaces in the Silurian rocks below.

Some of this calcareous material has been analysed by Mr. C. E. Crooke in the Agricultural Chemistry School, under Dr. Heber Green.

The result is as under :—

CaO	= 13.82%
MgO	= 8.01
Al_2O_3 and Fe_2O_3	= 0.46
Soluble SiO_2	= 0.31
Insoluble residue	= 55.18
Organic matter and CO_2 (after ignition)	= 19.70
Hygroscopic moisture (105°C)	= .06
Alkalies	= n.d.
	97.54

The low summation is probably due to the fact that the alkalies were not determined. Expressed as carbonates the alkaline earths are $CaCO_3 = 24.68$; $MgCO_3 = 16.82$. Total, 41.50.

The total expressed as oxides is 21.83. Organic matter is practically absent since the difference between these figures, viz., 19.67, practically agrees with the figures obtained for CO_2 and organic matter, viz., 19.70. The insoluble residue was obtained by digesting the limestone with hydrochloric Acid (strength 182.5 grams per litre).

Tertiary Dykes.—A dyke very much decomposed and basic in character occurs in the Silurian river cliff South of Bell Street bridge. It is about 100 feet away to the West of the axis of an anticline in the Silurian, which anticline strikes a little East of North. The dyke has the same strike, and dips 70 degs. to the West. Its age is probably Tertiary, and it is probably a member of the lamprophyric series of dykes found in other places penetrating the lower Palaeozoic series of Ballarat, Bendigo and Daylesford. At Coburg the relation of the dyke to the Tertiary sands is not clear. It appears, however, to be overlain, both by the newer basalt, and by the outcrop of Tertiary sands, which latter form a small outlier South of the Bell Street bridge. This would make the dyke pre-newer basaltic, and also pre-Tertiary sands. This would mean that it is connected not with the newer basalts, but with older earth movements, possibly those of the time of the outpouring of the

Victorian Tertiary alkalic basalts. In this connection F. L. Stillwell,[1] M.Sc., has suggested that this alkalic basalt horizon is the age of the monchiquite dykes, which come up along the anticlinal axes of Bendigo. Nowhere in the Melbourne district are dykes similar to that at Coburg found penetrating the Tertiary sands, so that the upper age limit of these dykes is certainly the horizon of the sands. As to the lower limit it is obviously Silurian. There is the possibility of the Devonian being the age of the dyke. The evidence of the other areas is against this, however, e.g., at Bendigo the quartz reefs are connected with the Devonian granodiorite to the South, and these reefs are frequently cut across by younger monchiquite dykes.

Tertiary Sands.—This series is composed for the main part of a system of unfossiliferous, iron-stained sandstones. Similar sand deposits are also found capping the Silurian hills in many parts around Melbourne, e.g., Studley Park, Kew and Hawthorn. At Coburg the finer grained beds have grains as much as 3 millimeters in diameter. Occasionally a coarser band of quartz pebbles occurs, pebbles up to 3 cm. in diameter being frequent. The series now occurs capping the hills. Its lower limit is about 160 feet above sea level. The series was laid down in pre-basaltic time, the area uplifted and the sands partly eroded away before the outpouring of the basalt. Whether they are of marine or fresh-water origin still remains a problem. Many of the grains are angular, indicating a source near at hand.

The basalt filled up the low level portions of the area, which portions were low lying, partly because their burden of sands had been eroded away. Hence it is difficult to get the relation between the basalt and the sand series. However, in places, e.g., on the banks of the Merri North of Pentridge, basalt is seen to overly a thin deposit of quartz pebbles, which again, rest on Silurian. This pebble bed is probably re-sorted Tertiary sands, and the basalt a later formation than the sands.

A sample of the fine sand deposit was taken and boiled in hydrochloric acid to get rid of the ferruginous coating. The sand was then washed in water and agitated, so getting a division into coarse sand and fine sand. This latter was then dried and examined under the microscope. It consists almost entirely of quartz grains, but there is a very slight content of a black mineral. Some of this is strongly magnetic, and hence is magnetite. Other

1. Proc. Roy. Soc. Victoria, vol. xxv. (n.s.), 1913, p. 1.

crystals are not so magnetic, and are probably ilmenite. Then again some of the crystals are not magnetic at all, but they show pleochroism, high polarization colours, and all the characters of tourmaline. The coarse sands were then examined, and a non-magnetic black crystal picked out and examined chemically. This examination showed the presence of iron and boron, thus confirming the presence of tourmaline. This presence of magnetite, ilmenite and tourmaline is not very important from the point of view of origin of the sands, as they occur in such small quantities. However, it is interesting to note that N. R. Junner,[1] B.Sc., finds them all in the Silurian sediments of Diamond Creek to the North-East of Coburg.

North of the Coburg cemetery in the V-shaped outcrop of this series a small watercourse only 400 yards long has given rise to miniature buttes and canyons. The boundary of sands and Silurian is V-shaped, with the apex of the V pointing Westwards. This is due to the sands filling up a depression in the Silurian, possibly a pre-Tertiary stream valley. After the uplift of the area following the deposition of the sands obliterating this stream, this little local area was placed in a very unstable state as regards erosion. It only required the digging of a gutter, some few years back, for water to get a start down the site of the old pre-Tertiary stream. The result has been a very rapid deepening of the bed of the present watercourse, so that now it is in places 20 feet deep, and everywhere has vertical walls. A short distance down from the highest portion of these "bad lands" the stream in places has up to four parallel paths, each separated by a few yards. During storms water flows rapidly at the bottom of these watercourses, often 20 feet below the surface, and rapidly undercuts the soft sands. The result is that often the different courses converge towards one another, and further down the hill unite in various places, forming a complicated network of watercourses under the hard surface of matted soil on top. This top hard surface is often undercut to such an extent that it caves in, leading to the formation of little islands or buttes. These buttes are generally only a few feet in diameter, and stick up as pillars sometimes 20 feet high. They are protected from rapid erosion by the top hard crust.

Discussing this area in 1906 Dr. Leach[2] emphasises the importance of surface tension in the formation of these "bad lands." He

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1. Proc. Roy. Soc. Victoria, vol. xxv. (n.s.), Pt. ii., 1913, p. 333.
2. Proc. Roy. Soc. Victoria, vol. xix. (n.s.), Pt. ii., 1907, pp. 54-59.

states that the water is in too small a quantity to splash about. During storms this is not so, but usually, however, the quantity is only small, and as the run off after a storm dies away, the water merely trickles over the edges, and then undoubtedly surface tension comes into play. However, surface tension alone can only explain the formation of a vertical face, and it is difficult to explain the complicated system of watercourses at Coburg by any other agent than running water. Erosion as pictured by Dr. Leach is necessarily a slow process, and it is most probable that the water running over the canyons after a heavy fall of rain, does more erosive work than six months of water just trickling over. During some periods of the year several months may elapse during which no heavy rain occurs. During this time surface tension is steadily at work after showers of rain, and certainly gives the walls of the canyon those characteristics enumerated by Dr. Leach. These, however, are more or less obliterated after the next heavy fall of rain.

The exact stratigraphical horizon of this sandstone series is difficult to determine, for they are unfossiliferous. One has to leave Coburg and examine neighbouring localities. At Royal Park, to the South, a similar series appear to overly a fossiliferous bed outcropping in the railway cutting. This latter series is generally regarded as Kalimnan in age. Also at Keilor in Green Gully thick, unfossiliferous sands overly thin beds of highly fossiliferous limestones of Barwonian and Kalimnan age. The horizon of the Coburg sands then appears to be post-Kalimnan and pre-newer basaltic.

Newer Basalt.—This occurs in the West of the area. Petrologically it can be divided into two types—(a) Low level, (b) High level.

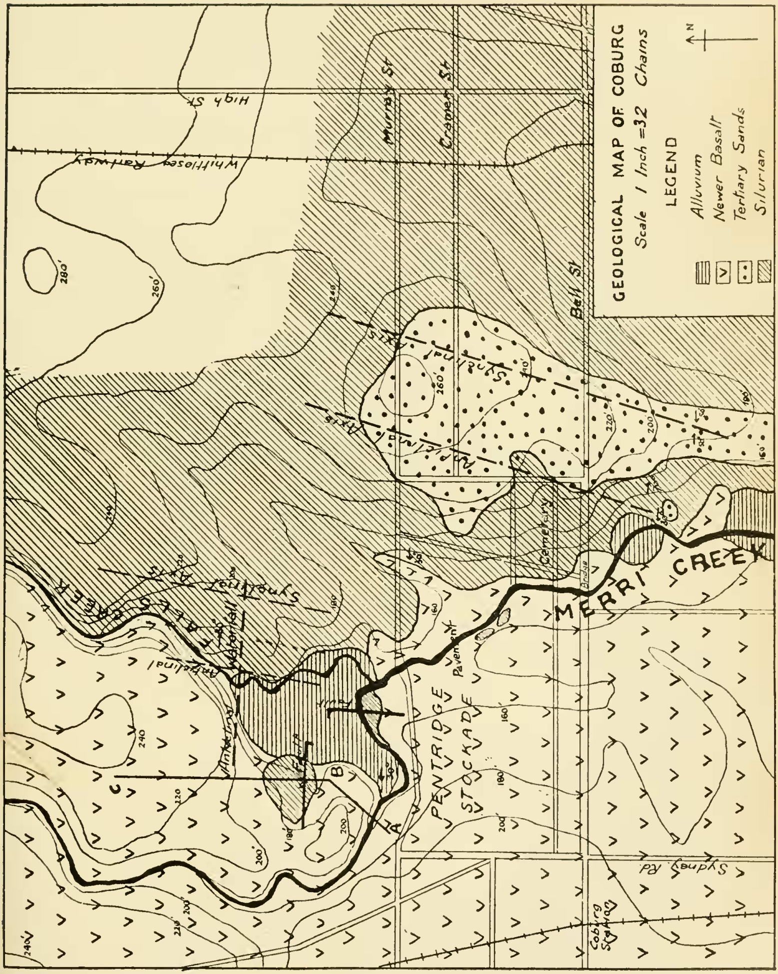
(a) Low Level Type.—The low level basalt is chiefly found filling up the pre-basaltic depressions, such as river beds, etc. In the hand specimen the rock is compact and medium fine grained, with a few small phenocrysts of olivine. In the bed of the Merri just East of Pentridge, it exhibits columnar jointing, seen in a basalt pavement. A study of this particular pavement shows that the cracks radiate in threes from a centre, and at various angles to one another. The angle between cracks in this limited exposure is always greater than 90 deg., so that the prisms in plan are never less than five-sided. The centres frequently seem to be joined by a crack, making the other cracks symmetrical about it. The result is that the five cracks resemble the arms of, say, Tetragraptus quadribrachiatus. The distance between centres varies from 2 inches to 24 inches.

Microscopically the rock from this pavement is typical of the low level basalt found in the area. Olivine is sparingly present in large, perfectly fresh phenocrysts. Light green augite is very plentiful in smaller crystals. A feature of the rock is the ophitic structure, which this augite shows with plagioclase needles. These latter are very plentiful, and show typical flow-structure. The angle of extinction of the lamellae of a number of laths has a maximum of 30 deg. This would indicate labradorite. There is also a very slight content of another untwinned felspar. This has very low polarization colours, and a very low extinction angle. It is possibly anorthoclase, which F. L. Stillwell[1] finds in the newer basalt at Broadmeadows. An examination of a number of slides would be necessary to confirm its presence. The order of crystallization was olivine first, then plagioclase, and then augite; for large crystals of olivine are frequently seen completely surrounded by aureoles consisting of ophitic augite and labradorite.

Oxide of iron is also rather frequent in the rock. The majority of the crystals are long and needle shaped, and hence most of them are ilmenite.

Glass, dusty green in colour, and containing many needles of ilmenite, is also very common. This high glass content is typical of the low level basalt in the area. The rock at the pavement also contains a fairly large content of a greenish-brown zoned material filling up what appear to be cavities. Under crossed nicols this material shows low polarization colours masked by the greenish colour of the mineral. No clear interference figures are obtainable, probably due to the material being an aggregate of small crystals. It is faintly pleochroic. Another characteristic is that it is invariably associated with the glass in the rock. It is probably chlorite.

1. Proc. Roy Soc. Victoria, xxiv. (n.s.), Pt. i., p. 159, 1911.


GEOLOGICAL MAP OF COBURG
Scale 1 Inch = 32 Chains
LEGEND
Alluvium
Newer Basalt
Tertiary Sands
Silurian
N
High St
Whittlesea Railway
Murray St
Bell St
Cemetery
MERRI CREEK
PENTRIDGE STOCKADE
Pavement
Waterfall
Sydney Rd
Coburg Station